CMS Center and CMS Research

Lothar A. T. Bauerdick

FRA Visiting Committee

April 20/21 2007

Content

- Status of the CMS Experiment
  - CMS Installation, Commissioning and Integration
  - Getting Ready for Physics
- Status of Fermilab CMS Center
  - CMS Center Organization
  - LHC Physics Center
  - Remote Operations Center

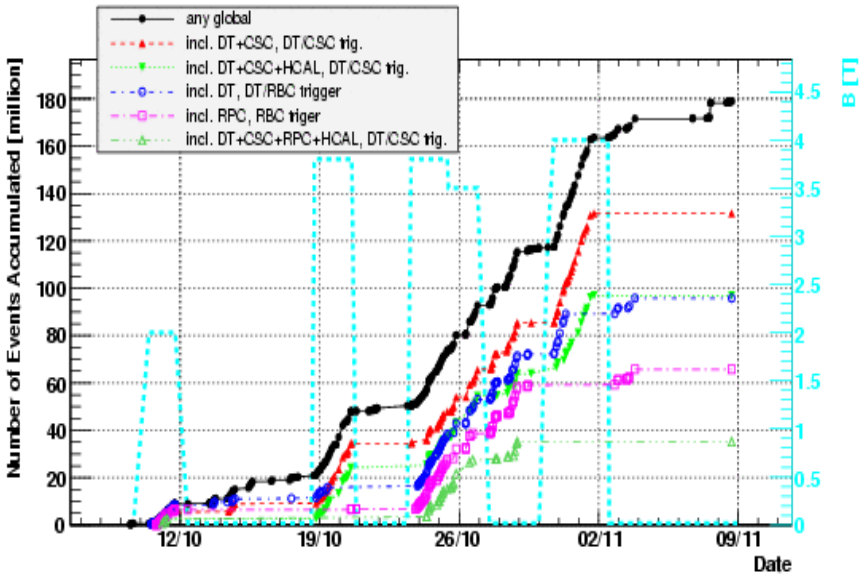
LHC Schedule

- March 2007 — Last LHC Dipole Installed
- Aug 31st, 2007 — Machine and experiments closed
  - CMS preferred schedule v35.3 has BP closed/baked out by Oct 15
- Nov 2007 — Pilot Engineering Run
  - Multiple bunches (43) in each ring, injection optics (β*= 11 m in IR 1 & 5)
  - No squeeze, no crossing angle, experiment magnets off at the start
  - First Collisions, for a few fills
  - Secondary goals: commission ramp to 1TeV, crossing angle, 75ns beams
- April 2008 — Pilot physics Run
  - first collisions at 14 TeV, 75ns commissioning down to 25ns
- Prospects for Integrated Luminosity
  - 2008 1 fb^{-1}
  - 2009 5 fb^{-1}

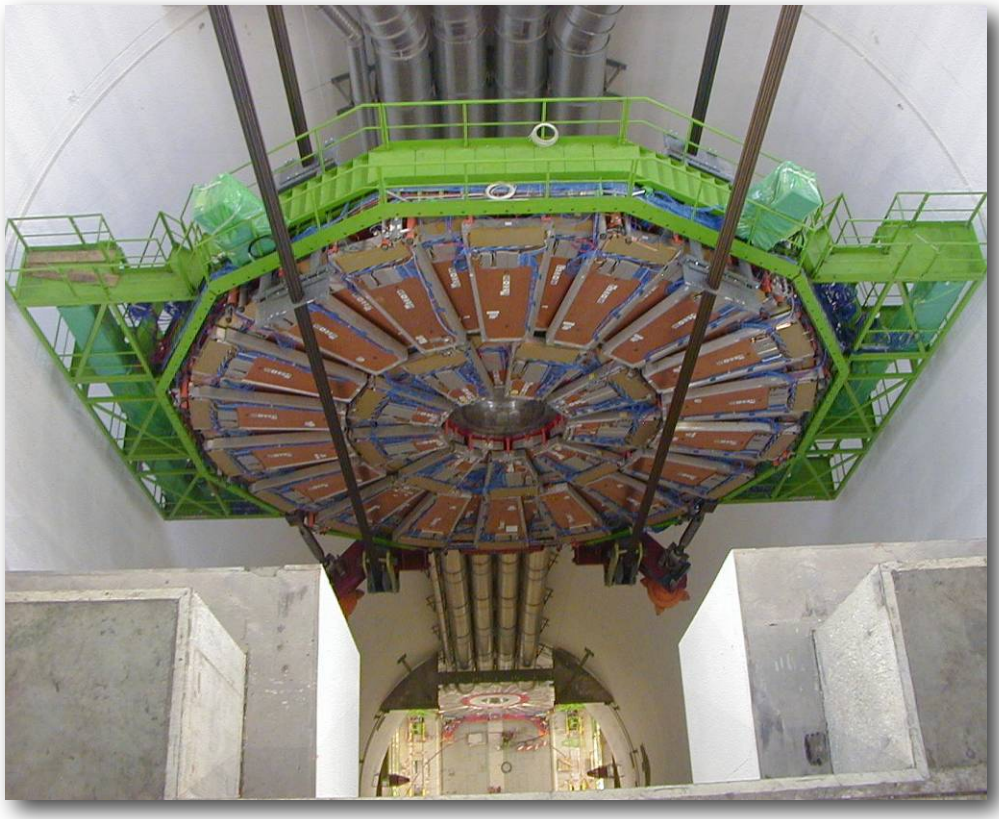
CMS Installation and Commissioning: Endcap Muons

- Stable Operation above ground — 24/7 shift crew operation
- Large amount of cosmic events recorded for various B-field settings
- Muon Endcap actively participated both in the trigger and data readout

Taking Cosmic Data above ground: MTCC

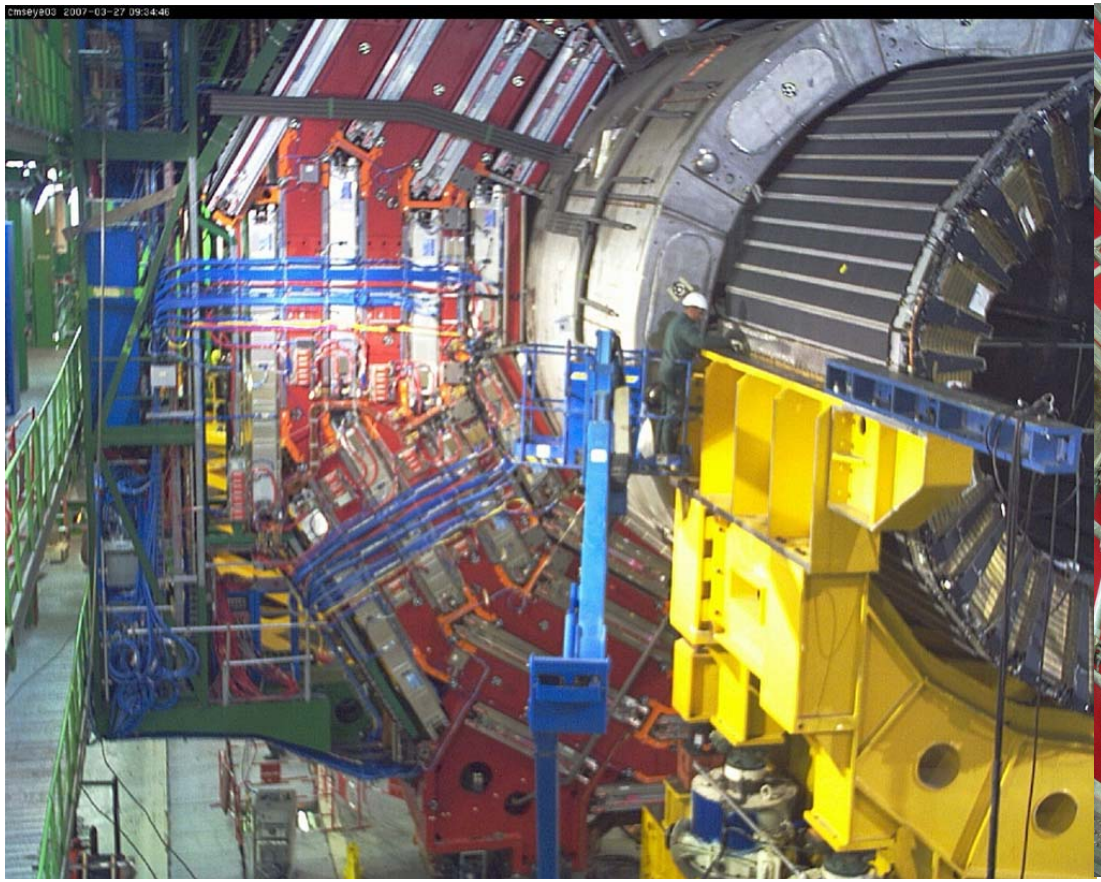


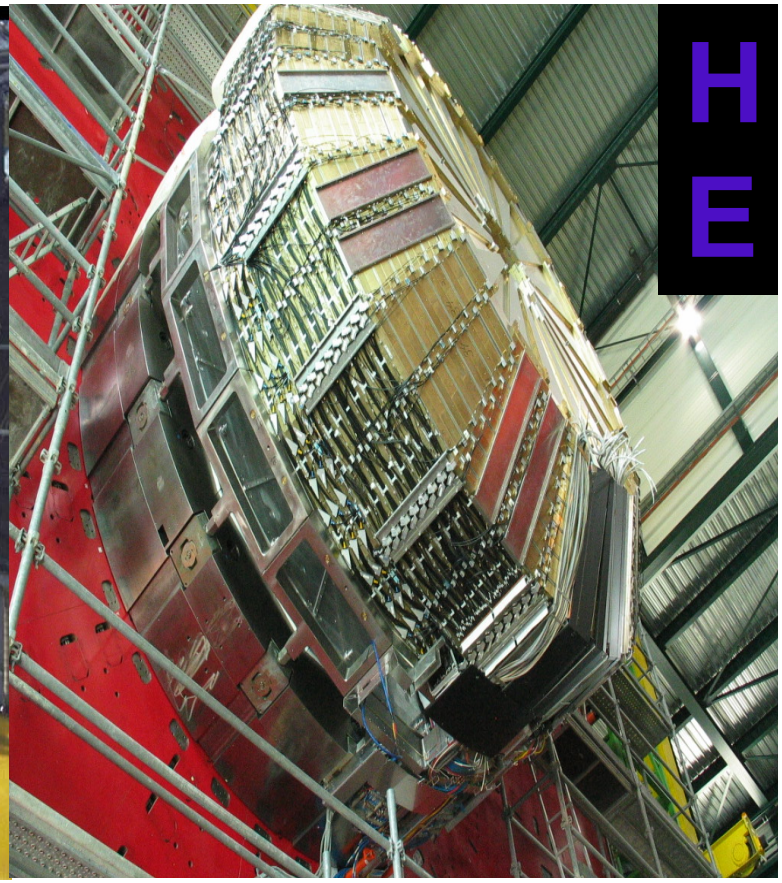
YE+2 Lowering (Dec 12)



HCAL Is Complete!

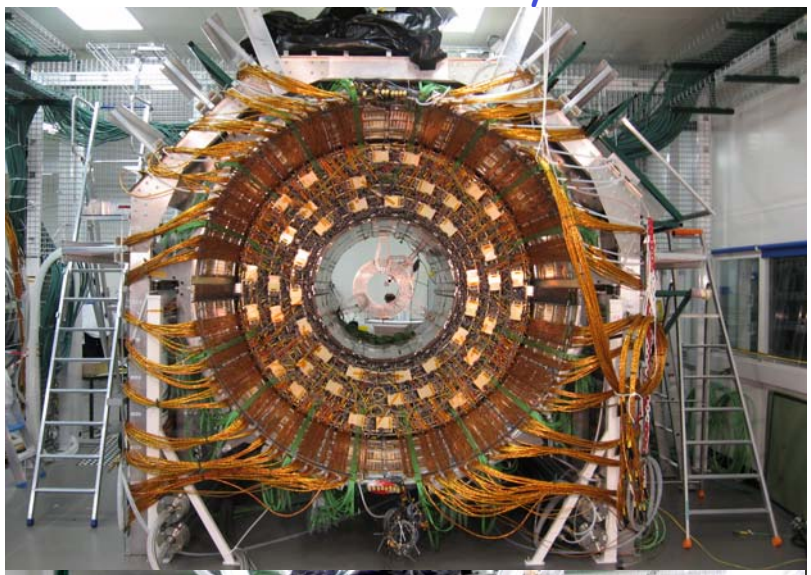
- Detector ready and installed — Barrel installed into YB0
- Good progress with installation in UndergroundServiceCavern
- Global Readout tests with HF being successful
- Problem with Noise in HPDs being worked on

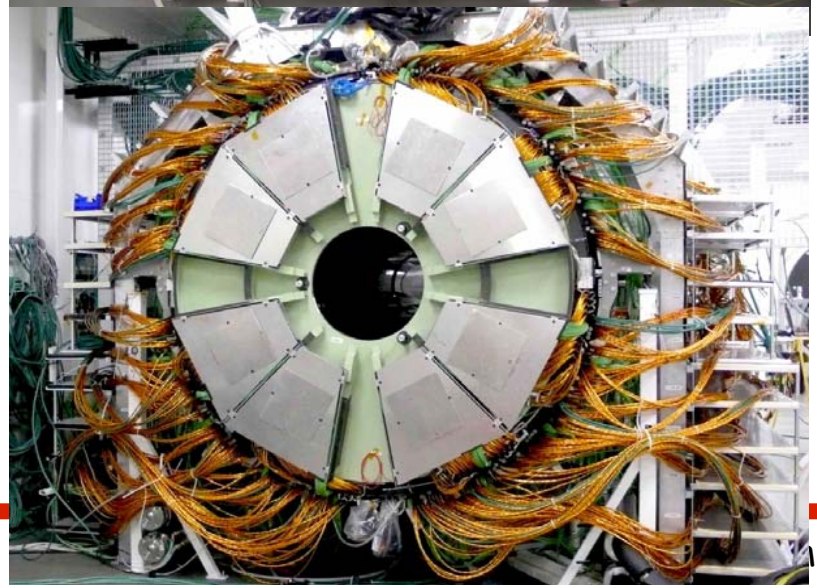


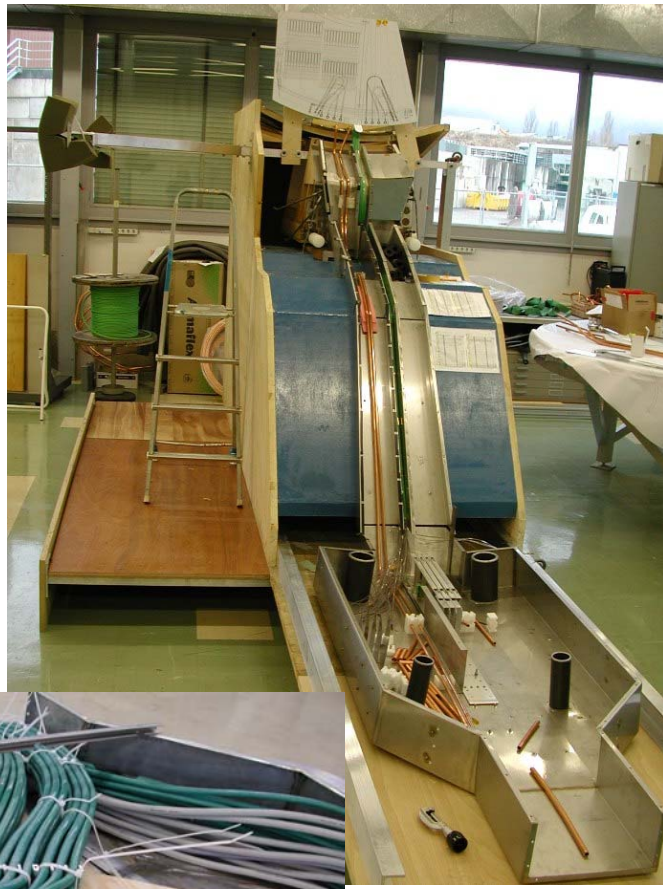


Silicon Strip Tracker Complete at TIF

- Tracker Integration Facility
- Slice Test underway: Cosmics w/ warm and cold detector

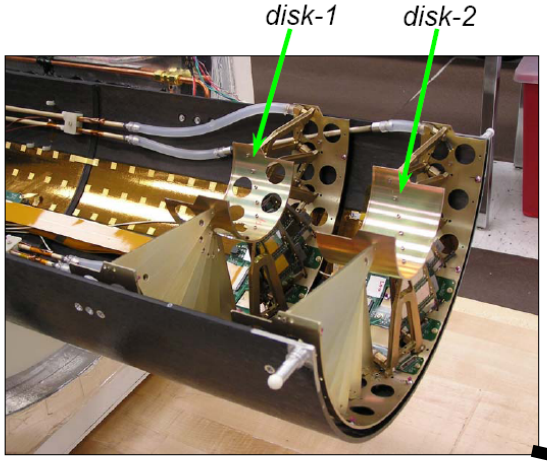




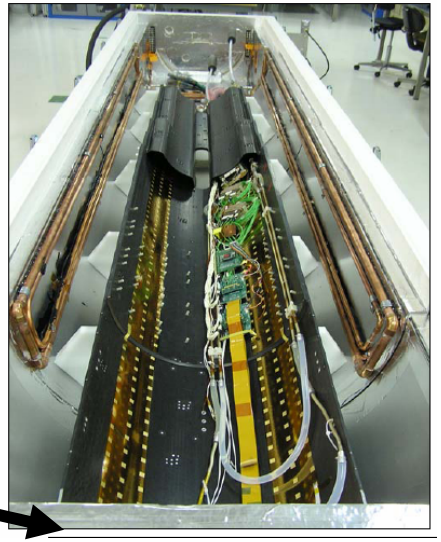


Forward Pixel Pilot Run Detector is at CERN

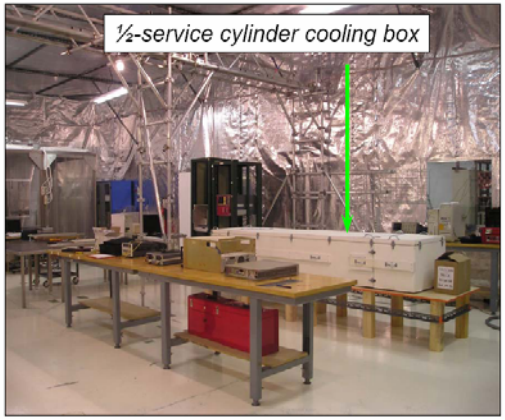
The pilot run detector was fully assembled and tested at Fermilab, then shipped to CERN



Environmental Chamber and half-cylinder at CERN (PIC)



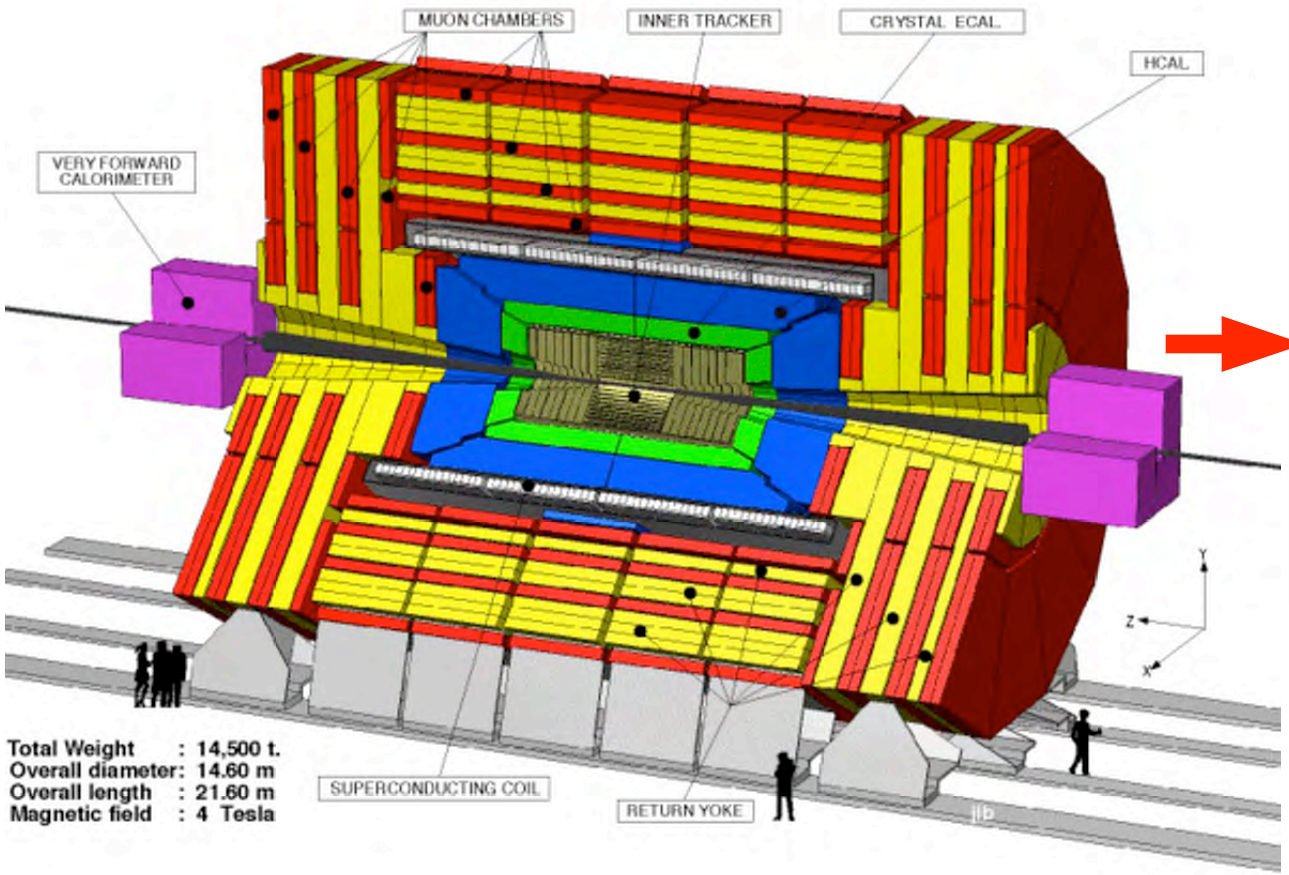
- Petal Integration Facility (PIC), next to the Tracker Integration Facility (TIF)
- Location where we will (re)commission FPIX



First of 8 production Half-rings. 2nd now also complete. 3rd being assembled

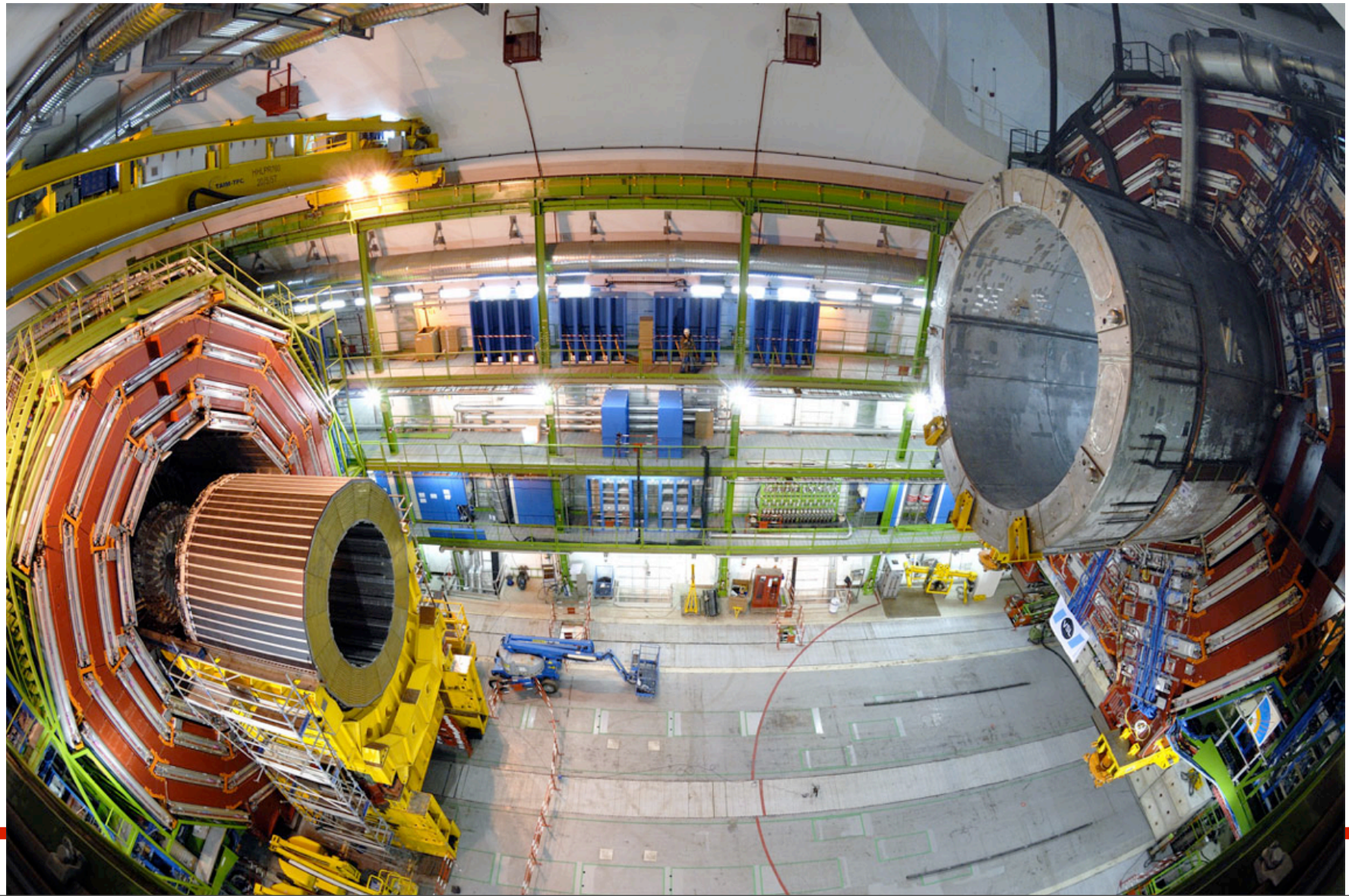
Putting Together CMS Underground

- Assembling CMS in the underground cavern out of 15 huge pieces
  - biggest central slice YB0 w/ coil cryostat ~ 2000t



Section	CMS Designation	Weight in tonnes
1	HF+	250
2	YE+3	410
3	YE+2	880
4	YE+1	1310
5	YB+2	1250
6	YB+1	1250
7	HB+	700
8	YB0	1920
9	HB-	700
10	YB-1	1250
11	YB-2	1250
12	YE-1	1310
13	YE-2	880
14	YE-3	410
15	HF-	250

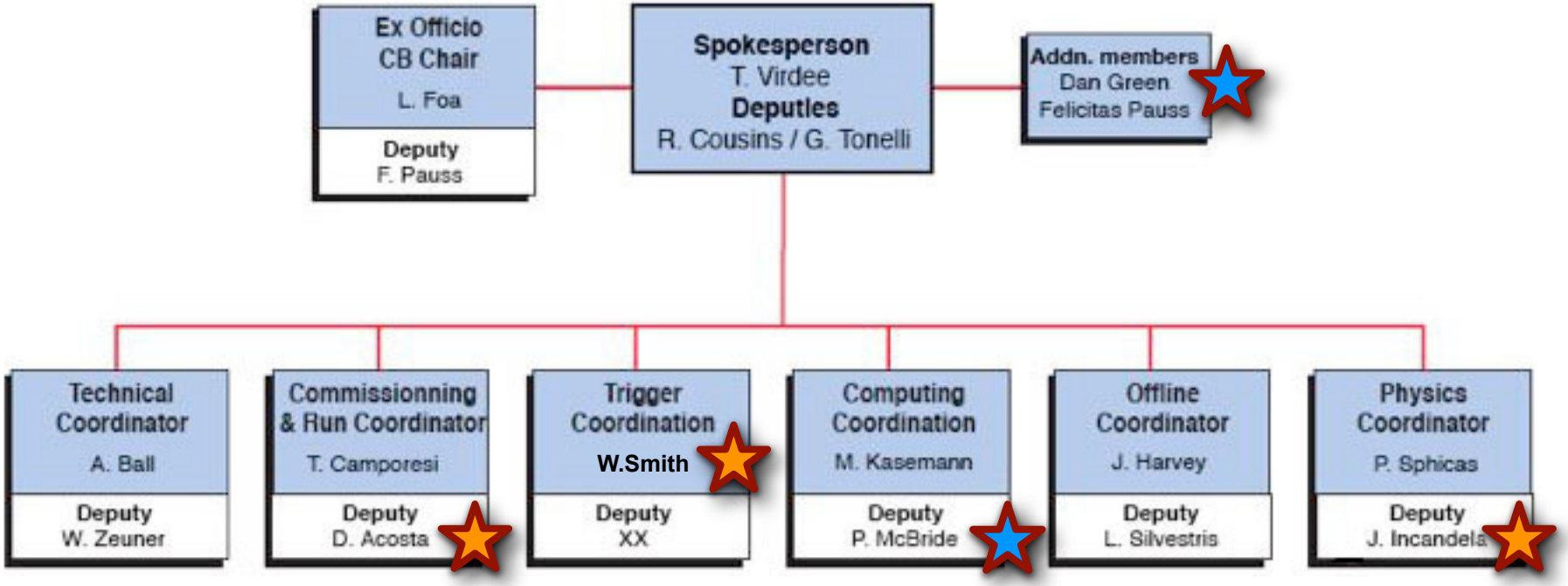
Feb 28: YB0 lowered



CMS Schedule

- CMS objectives
  - 900 GeV Collisions - Nov 2007
    - initial CMS detector (no ECAL Endcaps, pixels) ready to take data
    - commission and operate detector, and prepare collab for data taking and analysis
  - 14 TeV Collisions - June 2008
    - low lumi detector commissioned and ready for efficient physics data taking, collaboration trained and ready for analysis of data at 14 TeV
- Extremely tight schedule
  - 30 Aug 07 Beam-pipe closed
  - 16 Jul 07 Commissioned Tracker Ready for Installation
  - 1 April 07 >50% of detector lowered, HB+ and HB- installed in YB0
    - critical activity: install all services, cabling etc in central part of detector to ensure tracker is installed in time and CMS be closed for 900GeV run
- Following CMS request, Fermilab is making a special effort to provide additional help so we can meet the schedule

Organizing CMS for Data Taking and Analysis



- Physics, Offline, Computing, Trigger, Commissioning/RunCoord
  - Detector Performance Groups (reporting to Commissioning/Spokesman)
  - Physics Object Groups
  - Physics Analysis Groups
  - Offline project
  - Computing project
  - Cross activities for integration

CMS Commissioning and Integration

- Big Common challenges for all subsystems
  - new common organization with T. Camporesi and D.Acosta
    - hardware and online commissioning: central DAQ, global trigger, slice tests with some detectors — few days of global running every 4 weeks
    - thinking through run organization and needs -- collaboration participation
    - overseeing and getting effort from Detector Performance Groups
    - Alignment / calibration group, monitoring and DQM, global views
    - Luminosity, delivery of lumi information
    - preparations for LHC engineering run data taking
  - Commissioning effort has been ramping up steadily
    - from single detector commissioning focus on global activities in USC and single detector slice tests (e.g. HF full chain readout)
    - DPG become operational — global rendez-vous through global runs
      - hardware — offline — computing
    - engineering run is their main target: use it to verify that we have all it takes to exploit successfully the physics run of 2008
- Fermilab to contribute strongly to CMS commissioning
  - including personnel at CERN and work at the local ROC

US Teams at CERN and in the US

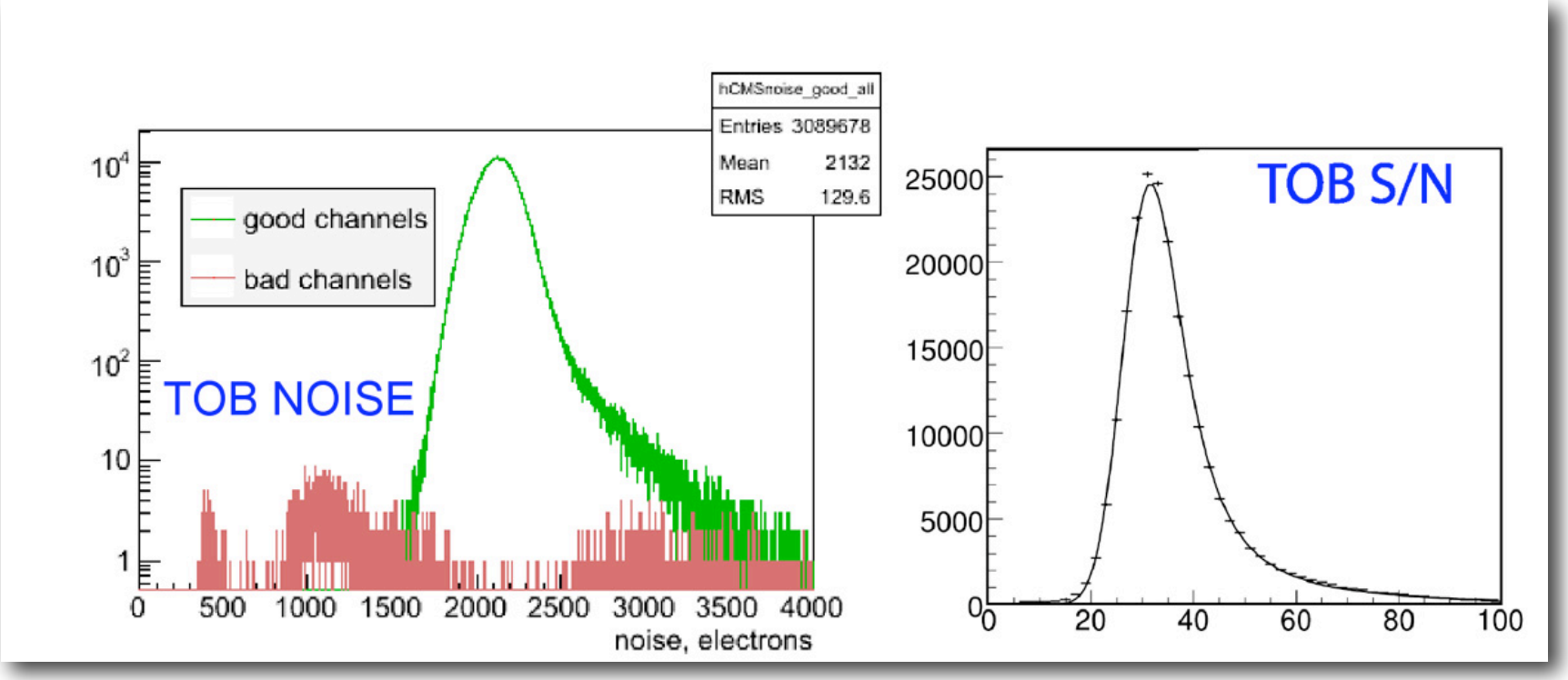
- Need to get excellent teams of physicists and engineers properly located and supported to effectively contribute to CMS operations and analysis

- Example of US Tracker Group: large Fermilab contribution
  - more than 15 physicists, engineers and technicians at CERN
    - Jeff Spalding (**FNAL**) involved in Tracker Integration.
    - Slawek Tkaczyk (**FNAL**) coordinator for Electronic Systems and Online Software.
    - Stefano Moccia (**FNAL**) lead engineer for Point 5 installation preparation.
    - Steve Nahn (MIT) Operations co-Coordinator for TIF with M. Eppard(CERN).
    - BrownU, UCSB, Riverside (UCR), and MIT scientists spent the last year testing the TOB during assembly and in the current slice test. They also initiated high rate tests that will advance the commissioning of the Tracker. These activities are supported by US-based physicists and engineers from UCSB, **FNAL** and Wisconsin.

US Teams at CERN and in the US

- "Inside the US many physicists are involved in monitoring and offline tasks
  - Lenny Spiegel (**FNAL**) and Lisa Shabalina U. of Illinois Chicago (UIC) lead a large, productive monitoring group, working out of Remote Operations Center (ROC)
  - Yuri Gotra (Rochester) co-leading data validation group with P.Azzi (Padova).
  - Scientists from Kansas and UCSB are working on the slow controls and error diagnostics for the tracker.
  - Kevin Burkett (**FNAL**) and Steve Wagner (Colorado) convene the **LPC offline tracking group**.
  - **FNAL**, UCSB, and UCR scientists are working on tracking code
    — e.g. HLT, and identification of converted photons.
    — have recently analyzed Cosmics data in the TOB and TIB.
  - Cecilia Gerber (UIC) and Meenakshi Narrain (Brown) convene the **LPC b-tag group**. "

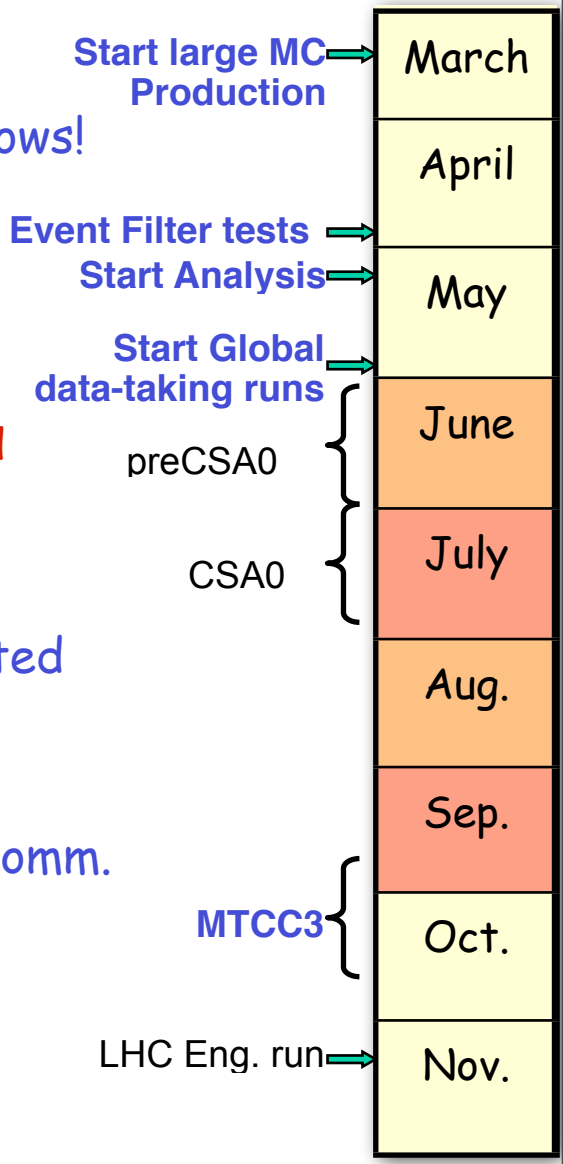
Example for Tracker Performance



- Cosmics Data Analysis: noise for all of the 3,089,678 channels of the TOB
  - "The performance is exceptional with only 2290 (0.07%) bad channels shown in red. The signal to noise ratio (S/N), seen at right, is typically over 30, as measured in the recent cosmics data taken with a slice of the TOB at the TIF by Pushpa Bhat (FNAL) and Yuri Gotra (Rochester)."

Computing, Software, Analysis Systems

- CSA06: Systems tested at 25%
  - End-to-end test, including main work flows and data flows!
    - 207M events/6 weeks processed in Tier-0
    - Calibration, Re-Processing, database access from the Grid
    - data export to Tier-1, analysis skim data to Tier-2
    - >50K/day production and analysis jobs on the Grid
    - Alignment/Calibration/Physics analyses widely demonstrated
  - All tests succeeded, down to the final analysis plots
- Next: getting ready for data taking
  - March — validation of re-engineered software completed
  - June — HLT exercise complete
  - October — First physics "papers" prepared
  - Plans for Software Releases and Computing Systems Comm.
    - Apr 2007: data taking with individual detectors
      - running cosmics with SiTracker, slice test HF
    - getting systems ready for global data taking
    - Continuing data taking plans until accelerator turn-on



Fermilab Tier-1 and Analysis Facilities

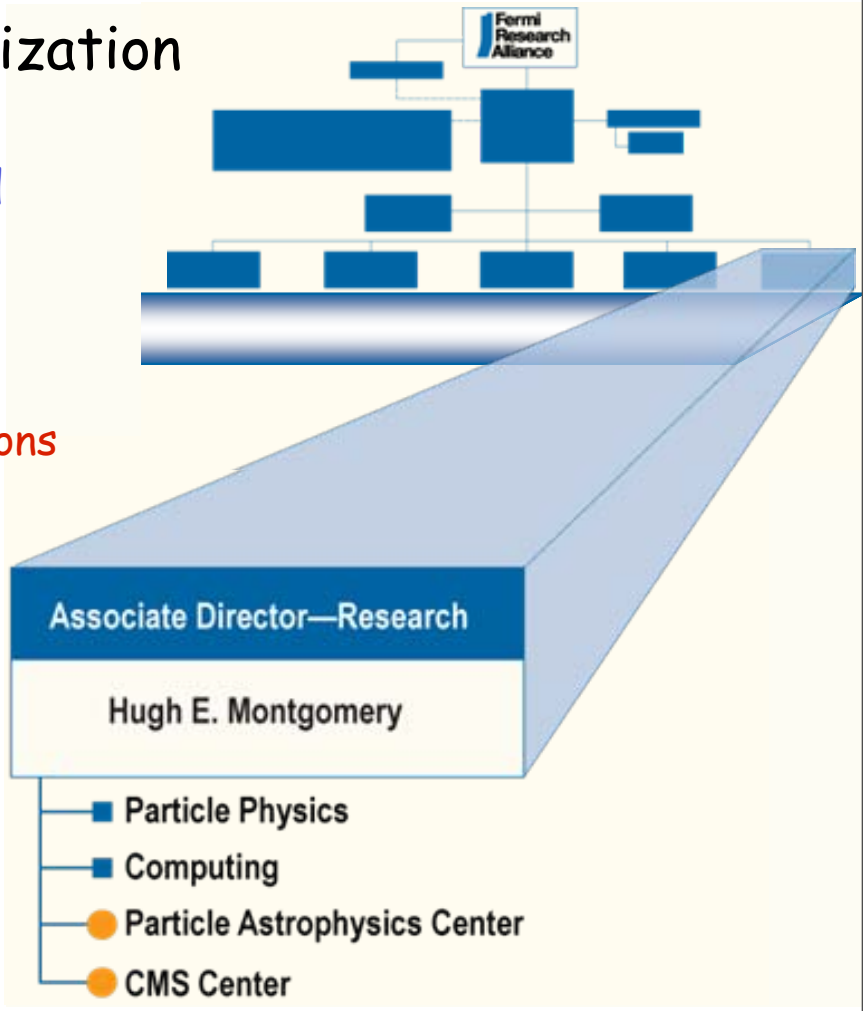
- Fermilab Host of major CMS Computing Facilities
  - one of the top places in the world -> see O.Gutsche's talk tomorrow
- CMS "2008 facility": Tier-1 + LPC-CAF
  - plan for 2008: 7.3 MSI2k, 2.5PB disk, 4.7PB tape (no change)
    - facility is now at roughly 2 MSI2k, roughly 1800 batch slots, 700TB of disk
    - Tier-1 has access to a 10G/s WAN link and 30GB/s of campus networking
- with slow LHC startup, push last phase procurements to FY08
  - facility still ready for 2007 running and start of physics data spring 2008
  - LPC-CAF (previously known as UAF) ramp-up this year
  - delays of procurement help w/ cost due to slow technology developments
- Fermilab also major Hub in Computing Grid for the LHC
  - Open Science Grid ready and funded to help university computing to get onto the Grid and become part of the CMS system
    - OSG milestone targeting getting ready for LHC start
- CMS software & computing systems becoming useable for physics at CERN, Fermilab, US Tier-2s and soon also at Tier-3s

CMS Upgrades for SLHC

- The SLHC schedule is not yet known.
  - We assume intermediate Pixel Detector 2011, and for full SLHC upgrade, complete the detector in 2014-2015 for installation during shutdown for machine upgrade in 2015-2016.
- Submitted an EOI for the CMS upgrade for SLHC to the LHCC
- USCMS has written a strawman plan for DOE
  - requests $145M funding starting in 2010 (corresponding to US share)
  - Expect heavy US involvement in
    new pixel, new tracker, track trigger, trigger upgrades.
    - USCMS RP starts to provide R&D funds to prepare for the upgrade
- Recent series of "upgrade workshops"
    - a Tracker Upgrade workshop in early Feb.
    - a common CMS-Atlas upgrade workshop on electronics for SLHC
    - sensor meeting, tracker readout meeting, CMS upgrade simulation meeting
- Fermilab is engaging in the CMS upgrade for the SLHC

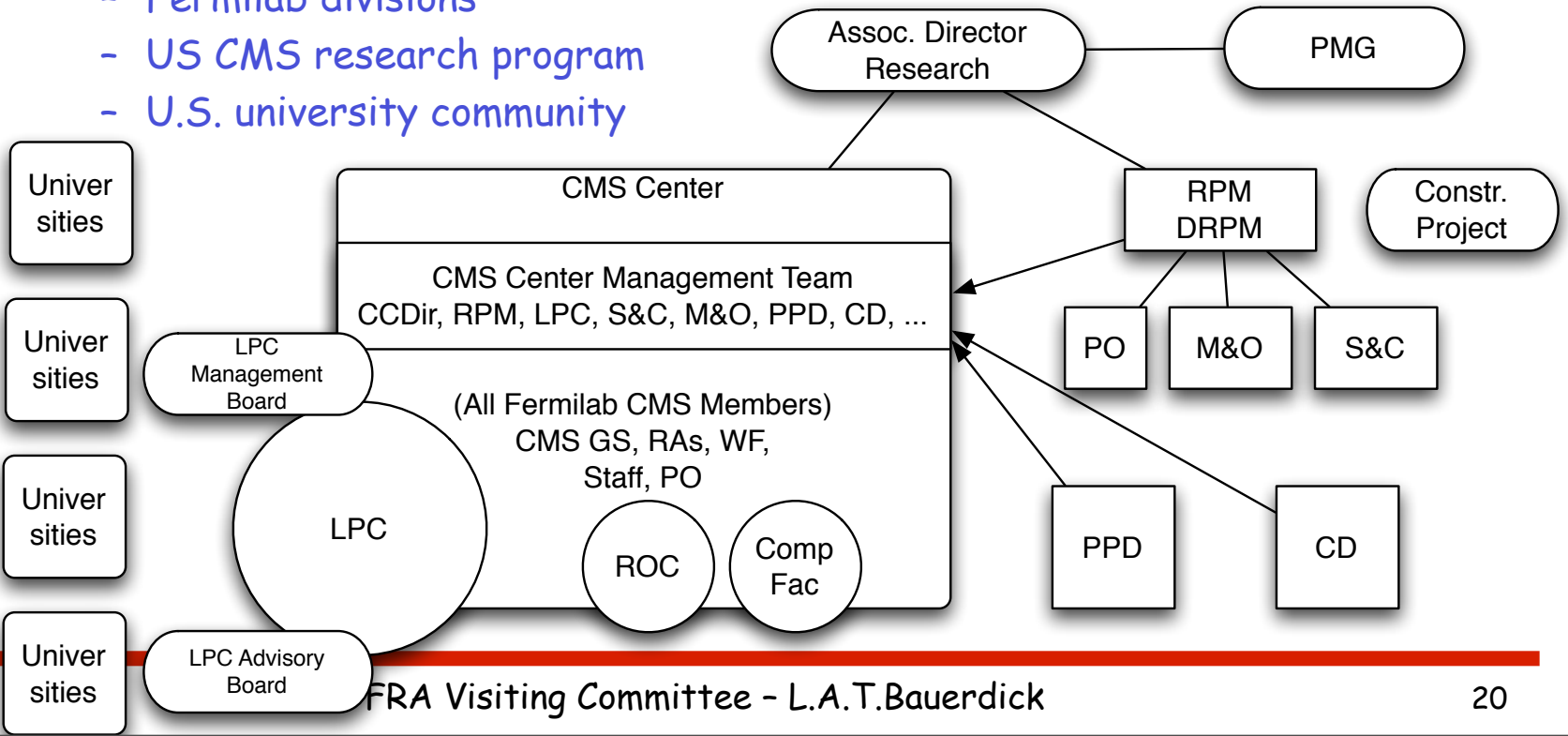
The CMS Center at Fermilab

- CMS Center part of new lab organization
  - Created the CMS Center in Dec 2006 to gather all the resources associated with CMS under one umbrella
    - reports directly to the Associate Director for Research
    - coordinates CMS efforts across divisions
  - Enhances U.S. ability to exploit the LHC and attracts physicists to FNAL during the LHC era
    - part of strategy to develop policies and tools that facilitate collaboration between FNAL and research performed elsewhere
  - LHC Physics Center LPC
  - Remote Operations Center ROC
  - CMS Tier-1 Computing and Analysis Facilities (LPC-CAF)
  - Research Program Management and Program Office



CMS Center Organization

- CMS Center Mission
  - To provide overall coordination and management of the Fermilab contributions to CMS and the resources invested in CMS
  - To ensure that the Fermilab and U.S. CMS enables U.S. physicists to fully and actively participate in the science made available at the LHC.
- CMS Center is home for all CMS people and efforts at Fermilab
  - a multi-dimensionally matrix-ed organization!
    - Fermilab divisions
    - US CMS research program
    - U.S. university community



CMS Center Organization Chart

- some 50 CMS physicists at Fermilab
  - including 3 Wilson Fellows and currently 7 postdocs
- CMS Center Management
  - Members:
  - CMS Center Director
  - PPD Liaison
  - CD Liaison
  - US CMS Research Program Manager
  - US CMS S&C Manager
  - US CMS M&O Manager
  - LPC Coordinators
  - meeting on a weekly basis

Draft CMS Center Organizational Chart

CMS Center Management Board

BAUERDICK, Lothar A.T. – CMS Center Director
BUTLER, Joel – U.S. CMS Research Program
FISK Ian – U.S. CMS Software and Computing
FREEMAN Jim – U.S. CMS Maintenance and Operations
GREEN Daniel – PPD
MCBRIDE Patricia – CD
ENO Sarah, YAGIL Avi – LPC

Detectors

DAQ
O'DELL Vivian, L – PPD
SUZUKI Ichiro (CP) – PPD

HCAL
ALBROW Michael – PPD
ELIAS John E – PPD
FREEMAN Jim – CC
GREEN Dan – PPD
HANLON Jim – PPD
VIDAL Richard – PPD
WHITMORE Juliana, L – PPD
WU Wei Min – PPD
Jordan Damgov (S) – CC
Stefan Piperov (S) – CC
Efe Yazgan (S) –CC

Muons
APOLLINARI Giorgio, L – TD
GEURTS Frank J.M – PPD
BORCHERDING Fred – PPD
EARTLY David – PPD
YARBA Viktor – PPD

Pixels
ATAC Muzaffer – PPD
BHAT Pushpalatha – PPD
HAHN Alan – PPD
JOSHI Umesh – PPD
KWAN Simon, L – PPD
TAN Ping RA – CC
UPLEGGER Lorenzo RA – CC
(BUTLER Joel Nathan) – CC
BALDIN Boris (E) – PPD
LOS Serguei (E) – PPD

SiTracker
DEMARTEAU Marcel – PPD
JENSEN Hans – PPD
NOEDING Carsten RA – CC
SPALDING William J – PPD
SPIEGEL Leonard, L – PPD
TKACZYK Slawek – PPD
MOCCIA Stefano (E) – PPD

Physics Software

Muon reco
BLOCH Ingo RA – CC
JAMES Eric, L WF – CC

Tracking reco
BURKETT Kevin, L WF – CC
GUTSCHE Oliver RA – CC
YUMICEVA Francisco – CC

HCAL reco
(ELVIRA Victor Daniel) – CD
HARRIS Robert, L – CD

Simulations
Banerjee, Sunanda – CD
ELVIRA Victor Daniel – CD
YARBA Julia (CP) – CD
MRENNA Stephen – CD

DQM and Trigger
BERRYHILL Jeffrey WF – CC
MAESHIMA Kaori – PPD
BADGETT William (CP) – PPD

Core Software
CHEUNG Harry – PPD
DAGENHART Dave (CP) – CD
TANENBAUM William (CP) – CD
KOWALKOWSKI James (CP) – CD
PATERNO Marc (CP) – CD
SEXTON-KENNEDY (CP), L – CD

Distributed Applications
LUEKING Lee, L – CD
AFAQ M Anzar (CP) – CD
DYKSTRA David (CP) – CD
EVANS David (CP) – CD
GUO Yuyi (CP) – CD
LUKHANIN Gennadiy (CP) – PPD
SEKHRI Vijay (CP) – CD
WICKLUND Eric – CD

Physics I/S

Computing Facilities Tier-1, LPC-CAF, Grids
ALBERTS Marina (CP) – CD
BAKKEN Jon Alan (CP), L – CD
FAGAN David (CP) – CD
HOLZMAN Burt (CP) – CD
PETRAVICK Donald (CP) – CD
STIEHR Gary (CP) – CD
WU Yujun (CP) – CD
HESSELROTH Ted (CP) – CD
KAISER Joseph (CP) – CD
PORDES Ruth (CP) – CD
SFILIGOI Igor (CP) – CD
GAINES Irwin – CD

Offline Infrastructure
BAUERDICK Lothar A.T – CC
FISK Ian, L – CC
GUTSCHE Oliver – CC
KLIMA Boaz – PPD
MASON David – CC
MCBRIDE Patricia – CD
ABDULLIN Salavat (CP) – PPD
GARTUNG Patrick (CP) – CD
MARRAFFINO John – CD
RATNIKOVA Natalia (CP) – CD
(SEXTON-KENNEDY)(CP) – CD

Centers & Offices

LPC
YAGIL Avi – UCDS, CC
ENO Sarah – UMaryland, CC
ROC
GOTTSCHALK Erik – PPD
MAESHIMA Kaori, L – PPD
STONE Alan Lee (CP) – PPD
MOKHOV Nikolai – AD
Research Program Office
BUTLER Joel Nathan – CC
(FISK Ian) – CC
(BAUERDICK Lothar A.T) – CC
(FREEMAN Jim) – CC
HANLON Jim (CP) – PPD
KRAMER Tami (CP) – PPD
LUSIN Sergei (E) – PPD
NAHN Jen OC – CD
DOODY Tim (CP) – CD
Admin Support
Carrie Farver – PPD
Terry Grozis – PPD
Terry Read – PPD

CMS Center M&S Budget Request

- Initial budget request for FY07 ~$3M total M&S
  - To strongly participate in CMS commissioning and physics preparation
  - Travel to the experiment for >50 CMS physicists
    - travel to experiment is essential and a "cost of doing business" at the LHC!
    - "be there" for commissioning, strengthening ties CERN—FNAL, CMS—LPC
  - M&S for infrastructure supporting >50 CMS physicists (in divisions)
    - conferences, computer replacements, software
  - M&S budget request for CMS program
    - M&S for LPC travel of invitees, buy-outs, housing, workshop support
    - COLA for long-term stays of physicists at CERN
  - M&S for SLHC and other R&D of CMS members
  - Guests and Visitor budget request
    - LPC guest, fellows, exchange program
    - important goals to build up the LPC at faster pace as we get close to running
    - GS and visitors for HCAL, Pixel, SiTracker, Software
- Initial M&S budget allocation received!
  - together with budget for CMS activities in PPD, CD budget is at ~ 75%

US CMS Research Program

- Fermilab is Host Lab for the U.S. CMS Research Program
- New RP Leadership in place
  - Joel Butler/Fermilab RPM, Dan Marlow/Princeton DRPM
  - Institutional Advisory Group and Technical Advisory Board
    - "advisory boards" to coordinate the Research Program efforts
- Successful reviews for S&C and M&O in Jan/Feb
  - JOG: funding agencies happy with US CMS management team
- Budget for FY07 ~ ok
  - monitor the M&O Cat-A costs (per capita cost)
  - help cover the Cost-to-Complete deficit for '08-'10, US share is 7 MCHF
  - shortfall 2008 Detector: Crystals, Common Fund, C&I ~ 17.5MCHF
  - Restore the full DAQ (4 Slices), DAQ Infrastructure ~ 8.4 MCHF
- RPM: will carefully evaluate S&C and M&O budgets in '08
  - look closely at M&O budget, projected data rates and computing needs based on better understanding of schedule, projected luminosity
  - will examine schedule of upgrades and needs for upgrade R&D

LHC Physics Center LPC

- The LPC was created for US physicists to make a strong contribution to the CMS experiment
  - a center with critical mass of scientists working together and resources to analyze CMS data and to commission and monitor experiment
  - a place to visit to get support and help with analysis and software issues
  - local center for shared effort on CMS and the Tevatron
    - help for a graceful transition between Tevatron experiments and CMS
- Fermilab provides strong support for the LPC
  - center of activity on 11th and 10th floor of the FNAL high rise
  - meeting rooms, video conferencing, computing facilities
  - access to CMS experts, contacts to Tevatron physicist, theorists
- The LPC is very active and attractive to U.S. Universities
  - some 60 University physicists at the LPC during last summer
  - 28 U.S. CMS Universities have offices at the LPC
  - working groups on physics objects, trigger, simulation, physics meeting
  - organizing workshops, tutorials, weekly US CMS meeting etc

LPC Attractive for US Universities

- ~50 University Colleagues at LPC Throughout last Summer

CMS TUTORIALS sessions

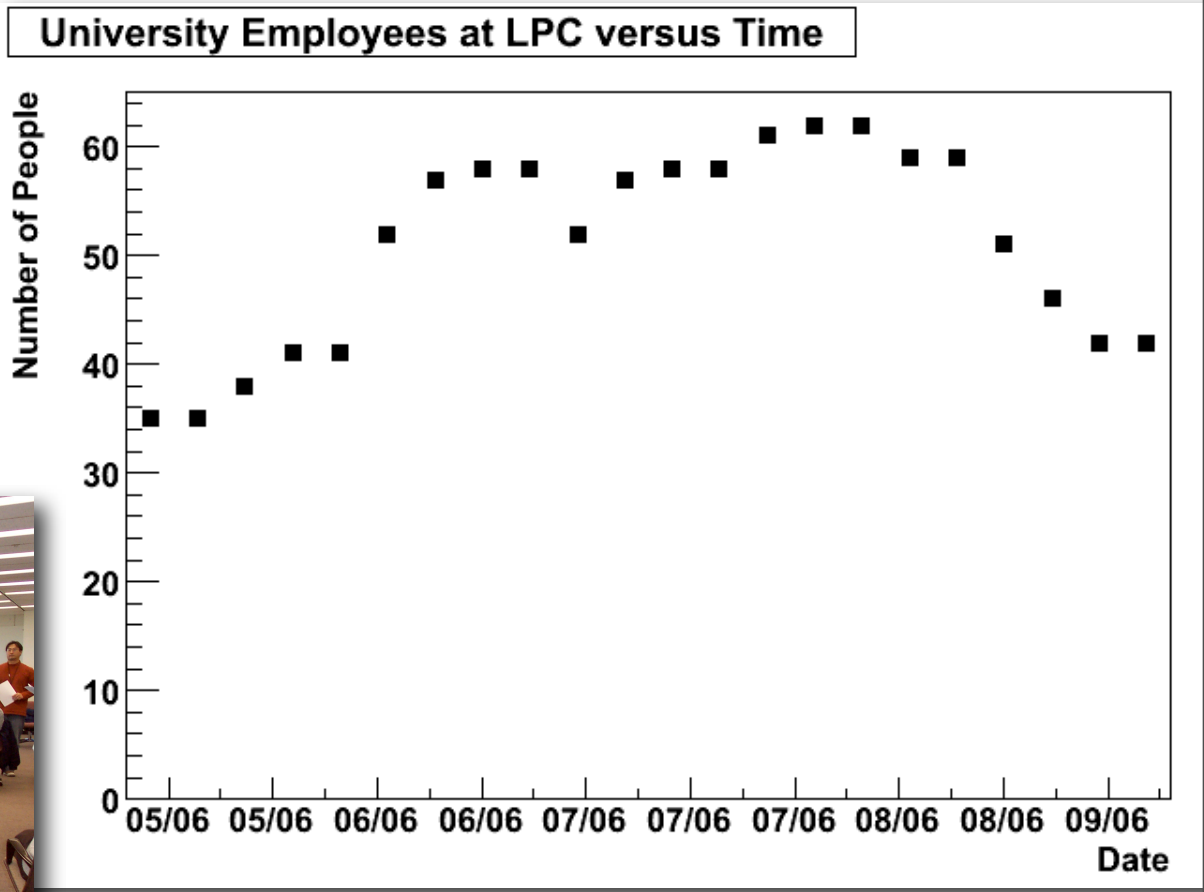
Mar 23, 2007: 21 participants

Nov 9, 2006: 26 participants

Jul 12, 2006: 40 participants

Jun 07, 2006: 37 participants

Plus 9 sessions of CMS101 since Sept 04



P. Sphicas,
CMS Physics
Coordinator

Summary

- From the "physics" side of things, we have high hopes that the LPC will contribute in very significant ways to the program of work of CMS.
  - And even beyond "physics", the LPC can take responsibility for major tasks in what can be called the "physics operation" of the experiment. Because it has three major ingredients:
    - the (human) critical mass,
    - the software expertise as well as
    - the computing resources
- Making CMS to work will be a real challenge, and will need all the experience, wisdom and ability in the collaboration.
  - And the LPC is a big fraction of the total EWA of CMS.

LPC Governance

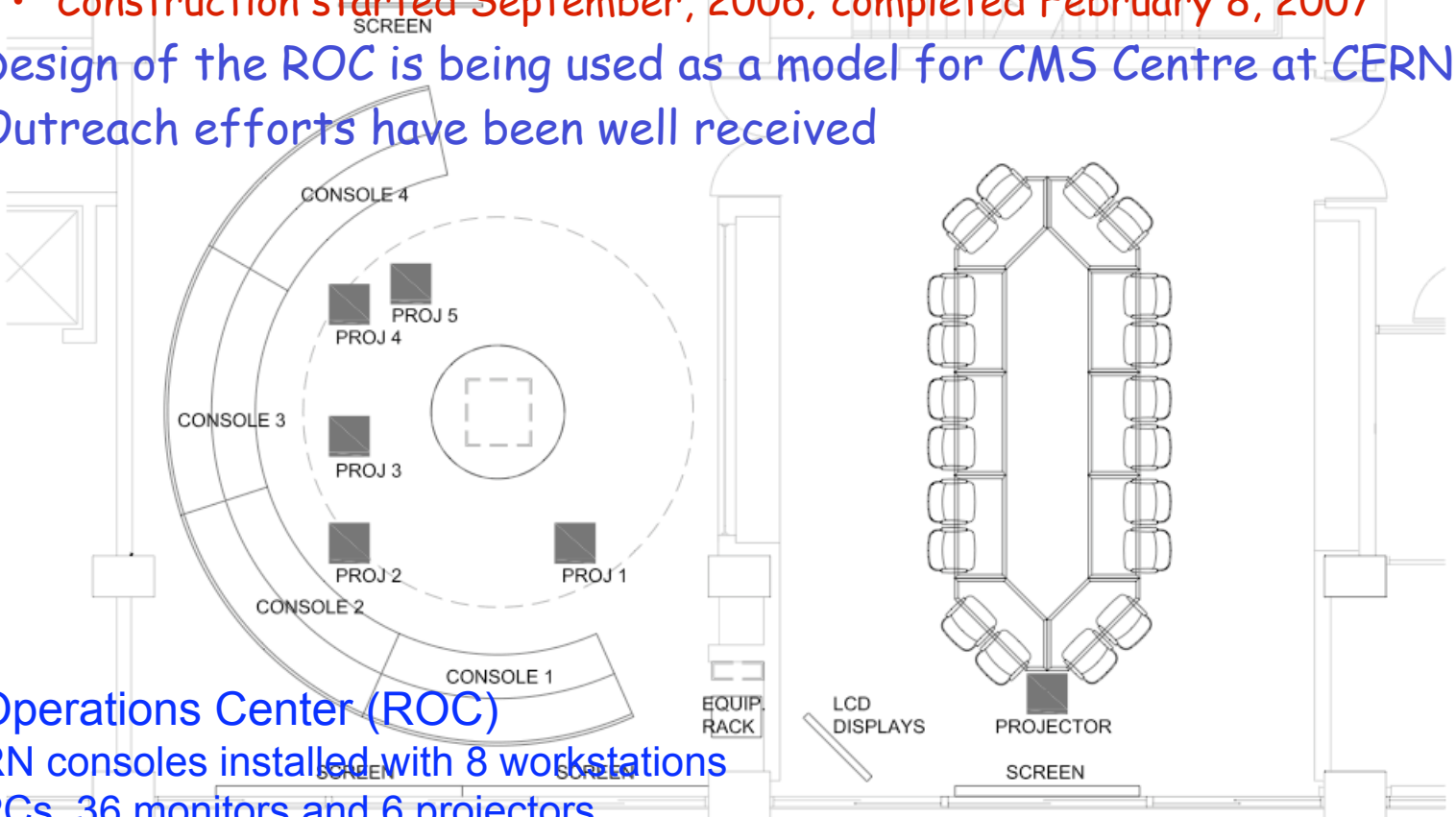
- Committee report advising on LPC structure and leadership
  - representation from USCMS, CMS, LPC, LPC-AB, CMS-CB
- Principal Recommendations
  - LPC to be led by two LPC Coordinators with staggered two-year terms
  - LPC Coordinator Selection Committee, identify short ranked list
    - candidates nominated by the U.S. CMS Collaboration
    - Fermilab Director to appoint the LPC Coordinators from the short list
  - LPC Management Board LPC-MB
    - chaired by the LPC Coordinators, to direct the LPC program of work, to draw up policies and to provide the forum for close coordination with activities in CMS, in U.S. CMS, and in the CMS Center.
  - LPC Advisory Board LPC-AB
    - provide advice to the LPC Coordinators, give regular feedback on LPC performance to the LPC-MB and report to the U.S. CMS Collaboration and Fermilab
- LPC Coordinator selection has started
  - time scale to have the appointments in June

CMS Remote Operations Center in LHC@FNAL

- Follow-up on a successful ROC prototype on WH11
  - e.g. important role in data taking during CMS Magnet Test Cosmic Challenge!
- New Location on WH1 in LHC@FNAL now in use by CMS Tracker Slice Testers, CMS Grid computing operations, LHC Operations Developers

LHC@FNAL Layout and Outfit

- LHC@FNAL construction was on time, under budget, with no injuries
  - Construction started September, 2006; completed February 8, 2007
- Design of the ROC is being used as a model for CMS Centre at CERN
- Outreach efforts have been well received



Remote Operations Center (ROC)

- CERN consoles installed with 8 workstations
- 16 PCs, 36 monitors and 6 projectors
- Video conferencing installed for two consoles
- Webcams installed for remote viewing
- Secure keycard access to the ROC
- Secure network for console PCs

Videoconferencing installed in 1-East

- Polycom VSX 8000 is installed.
- Upgrad to HD video conferencing with CERN control rooms.

LHC@FNAL for CMS

- Important opportunity for CMS, complementing LPC
  - enable US physicists to be successful contributors to CMS
  - make US physicists effective in providing "service contributions" to CMS
    - with the goal to do shift work from the ROC!
  - make Fermilab's contributions to the LHC visible and promote the LHC
- A Place
  - That provides access to information in a manner that is similar to what is available in LHC and CMS control rooms at CERN
  - Where members of the LHC community can participate remotely in LHC and CMS activities
- A Communications Conduit
  - Between CERN and members of LHC community located in North America
- An Outreach tool
  - Visitors will see current LHC activities
  - Visitors will see how future international projects in particle physics can benefit from active participation in projects at remote locations.

Summary

- CMS is coming together
  - in terms of components in the underground cavern, and as a whole experiment collaboration
  - schedule very tight, but CMS is holding to the plan for the moment
- CMS plan emerges for commissioning and operating detector, and to prepare collaboration for data taking and analysis
  - Fermilab to contribute as strongly and efficiently as we can
  - presence **at CERN** and facilities **at home** are key
    - strong Fermilab involvement in MTCC, CSA06, commissioning baby steps toward learning how to operate CMS for physics
- Fermilab organized CMS efforts in CMS Center
  - strategic decision to ensure a vital role for the US HEP community in the exploitation of the LHC physics program.
  - Major CMS roles for LPC, ROC, detector&software expertise, computing
- Fermilab strong contributor to get CMS ready for physics